



# PATENT COOPERATION TREATY

## PCT

### INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference <b>15931PCT00</b>	<b>FOR FURTHER ACTION</b>		See Form PCT/PEA/416
International application No. <b>PCT/DK2004/000704</b>	International filing date ( <i>day/month/year</i> ) <b>14.10.2004</b>	Priority date ( <i>day/month/year</i> ) <b>14.10.2003</b>	
International Patent Classification (IPC) or national classification and IPC <b>F03B13/18, F03B11/06, F16C27/06</b>			
Applicant <b>WAVE STAR ENERGY APS</b>			
1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36. 2. This REPORT consists of a total of 5 sheets, including this cover sheet. 3. This report is also accompanied by ANNEXES, comprising: a. <input checked="" type="checkbox"/> <i>sent to the applicant and to the International Bureau</i> a total of 4 sheets, as follows: <input checked="" type="checkbox"/> sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions). <input type="checkbox"/> sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box. b. <input type="checkbox"/> ( <i>sent to the International Bureau only</i> ) a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).			
4. This report contains indications relating to the following items: <input checked="" type="checkbox"/> Box No. I      Basis of the opinion <input type="checkbox"/> Box No. II     Priority <input type="checkbox"/> Box No. III    Non-establishment of opinion with regard to novelty, inventive step and industrial applicability <input type="checkbox"/> Box No. IV    Lack of unity of invention <input checked="" type="checkbox"/> Box No. V     Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement <input type="checkbox"/> Box No. VI    Certain documents cited <input type="checkbox"/> Box No. VII   Certain defects in the international application <input type="checkbox"/> Box No. VIII   Certain observations on the international application			
Date of submission of the demand  <b>02.05.2005</b>		Date of completion of this report  <b>22.12.2005</b>	
Name and mailing address of the international preliminary examining authority:   European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx: 31 651 epo nl Fax: +31 70 340 - 3016		Authorized Officer  <b>O'Shea, G</b>  Telephone No. +31 70 340-4424  	

**INTERNATIONAL PRELIMINARY REPORT  
ON PATENTABILITY**

International application No.  
PCT/DK2004/000704

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**Box No. I Basis of the report**

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1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.
- ☐ This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:
- ☐ international search (under Rules 12.3 and 23.1(b))
  - ☐ publication of the international application (under Rule 12.4)
  - ☐ international preliminary examination (under Rules 55.2 and/or 55.3)
2. With regard to the **elements\*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report):*

**Description, Pages**

1-22 as originally filed

**Claims, Numbers**

1-26 filed with telefax on 02.05.2005

**Drawings, Sheets**

1/23-23/23 as originally filed

- ☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing
3. ☒ The amendments have resulted in the cancellation of:
- ☐ the description, pages
  - ☒ the claims, Nos. 27-29
  - ☐ the drawings, sheets/figs
  - ☐ the sequence listing (*specify*):
  - ☐ any table(s) related to sequence listing (*specify*):
4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
- ☐ the description, pages
  - ☐ the claims, Nos.
  - ☐ the drawings, sheets/figs
  - ☐ the sequence listing (*specify*):
  - ☐ any table(s) related to sequence listing (*specify*):

\* If item 4 applies, some or all of these sheets may be marked "superseded."

**INTERNATIONAL PRELIMINARY REPORT  
ON PATENTABILITY**

International application No.  
PCT/DK2004/000704

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**Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

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1. Statement

Novelty (N)	Yes: Claims	1-26
	No: Claims	
Inventive step (IS)	Yes: Claims	1-26
	No: Claims	
Industrial applicability (IA)	Yes: Claims	1-26
	No: Claims	

2. Citations and explanations (Rule 70.7):

**see separate sheet**

**Re Item V**

**Reasoned statement with regard to novelty, inventive step or industrial applicability;  
citations and explanations supporting such statement**

1. Reference is made to the following documents:  
D1: US-A-5 986 349 (EBERLE ET AL) 16 November 1999  
D2: US-A-4 013 382 (DIGGS ET AL) 22 March 1977  
D3: US-B1-6 476 511 (YEMM RICHARD ET AL) 5 November 2002  
D4: WO 89/07197 A (BURTON, LAWRENCE, C) 10 August 1989
2. Document D1 is regarded as being the closest prior art to the subject-matter of claim 1, and shows (the references in parentheses applying to this document):

A wave power apparatus comprising:

a plurality of arms (54)(see figures 1 and 2), each arm being rotationally supported at one end by a shaft (48) and carrying a float (12) at its other end, which is opposite to the supported end; power conversion means (17,18,20) for converting power transmitted from the waves to the arms into electric power, the plurality of arms being arranged in a row(see figure 2), the arms being arranged at mutual distances apart (see figure 2); the power conversion means comprising a hydraulic driving system (see col.5, lines 54-64) with a hydraulically driven motor (18), wherein each arm is connected to the hydraulic driving system by means of at least one hydraulic cylinder (58) which is arranged to displace the hydraulic medium to the motor via common hydraulic conduits.

The subject-matter of claim 1 differs from this known wave power apparatus in that each cylinder is provided with a sensor for determining a position and/or rate of movement of the piston of the cylinder, the sensor being arranged to transmit a signal to a control unit of the cylinders and associated valves.

The subject-matter of claim 1 is therefore new (Article 33(2) PCT).

The problem to be solved by the present invention may be regarded as how to improve the controllability of the wave power apparatus.

The solution to this problem proposed in claim 1 of the present application is considered as involving an inventive step (Article 33(3) PCT) for the following reasons:

The presence of a sensor for determining a position and/or rate of movement of the piston of the cylinder means that each cylinder is individually controllable. This enables individual cylinders to be withdrawn from operation for any reason (such as maintenance) without interrupting the operation of the remaining cylinders, the apparatus being therefore essentially unaffected by the withdrawal of a single cylinder. The sensor also enables each cylinder to be selectively actuated into and out of the water. Furthermore, the power output of each individual cylinder of the driving system may be monitored and hence optimised. There are neither teachings nor hints in any of documents D2-D4 which would prompt the skilled person to apply the solution of the present claim 1 to the wave power apparatus of D1. The skilled person would therefore not consider it obvious to apply sensors to each piston of the wave power apparatus of D1 thereby arriving at an apparatus according to claim 1.

3. Claims 2-26 are dependent on claim 1 and as such also meet the requirements of the PCT with respect to novelty and inventive step.

## CLAIMS OF 2 MAY 2005 – FAIR VERSION

International application No.: PCT/DK2004/000704

Our ref. 15931PCT00

Applicant: WAVE STAR ENERGY APS

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## CLAIMS

## 1. A wave power apparatus comprising:

- a plurality of arms, each of which is rotationally supported at one end by a shaft, and wherein each arm carries a float at its other end, which is opposite to the supported end,  
10 so that a translational movement of the float caused by a wave results in rotation of the arm around the shaft,
- power conversion means for converting power transmitted from the wave to the arms into electric power, the plurality of arms being arranged in a row such that a wave  
15 passing the row of arms causes the arms to successively pivot around the shaft, the arms being arranged at mutual distances, so that the passage of the wave causes the arms to pivot with a mutual phase shift, the power conversion means comprising a hydraulic driving system with a hydraulically driven motor,

wherein each arm is connected to the hydraulic driving system by means of at least one hydraulic cylinder which causes a hydraulic medium of the hydraulic driving system to be  
20 displaced into the motor, the cylinders being arranged to displace the hydraulic medium to the motor via common hydraulic conduits,

characterized in that

each cylinder is provided with a sensor for determining a position and/or rate of movement of the cylinder's piston, the sensor being arranged to transmit a signal to a control unit of the  
25 cylinders and associated valves, so that the transmission of energy from each individual cylinder to the remaining parts of the hydraulic driving system is individually controllable in response to the signal representing the individual cylinder's piston's position and/or rate of movement.

2. A wave power apparatus according to claim 1, wherein the row of arms is oriented such  
30 with respect to the wave heading that the row forms an angle of within +/- 60° with respect to the heading.

3. A wave power apparatus according to claim 1 or 2, wherein each of the arms intermittently transmits power to the power conversion means when a wave passes the float of the arm, the arms and floats being arranged with such mutual distances that, at all times, at least two arms and floats simultaneously deliver a power contribute to the power conversion means.
- 5 4. A wave power apparatus according to any of the preceding claims, wherein buoyancy of the float is at least 10 times its dry weight.
5. A wave power apparatus according to any of the preceding claims, wherein the diameter of the float is at least 5 times its height.
6. A wave power apparatus according to any of the preceding claims, wherein the plurality of arms comprises at least five arms per wavelength of waves.
- 10 7. A wave power apparatus according to any of the preceding claims, wherein the plurality of arms comprises at least five arms spanning over a total length of 50 – 200 m.
8. A wave power apparatus according to any of the preceding claims, wherein the arms and the floats are made from a material which has a density of at most 1000 kg/m<sup>3</sup>.
- 15 9. A wave power apparatus according to claim 1, wherein the at least one hydraulic cylinder of each arm comprises a double-acting cylinder.
10. A wave power apparatus according to claim 9, wherein the hydraulic driving system comprises at least one hydraulic accumulator for intermittently storing energy in the hydraulic driving system, and wherein the hydraulic driving system is controllable to release the energy stored in the accumulator, when a float is passed by a wave trough, so as to force the float carried by the arm into the wave.
- 20 11. A wave power apparatus according to claim 1 and 10, wherein the hydraulic medium is fed to the hydraulic accumulator via the common hydraulic conduits.
12. A wave power apparatus according to any of the preceding claims, wherein the shaft and the power conversion means are supported by a supporting structure which is anchored to the sea floor by means of a suction anchor or a gravitational support.
- 25 13. A power apparatus according to claim 12, wherein the supporting structure comprises a truss structure, and wherein the suction anchor is arranged in a first nodal point of the truss structure.

14. A wave power apparatus according to claim 13, wherein the at least one arm is supported by the truss structure in a second nodal point thereof.
15. A wave power apparatus according to claim 14, wherein said second nodal point is arranged at a summit of a triangular substructure of the truss structure, and wherein the triangular substructure defines two vertices at the sea floor, with an anchor in each of the corners.
16. A wave power apparatus according to claim 15, wherein the truss structure comprises a polygonal substructure, preferably a rectangular substructure, arranged above the triangular substructure.
17. A wave power apparatus according to any of claims 12-16, wherein the supporting structure comprises a ballast for providing a downward force on the supporting structure, the ballast being arranged above sea level.
18. A wave power apparatus according to claim 17, wherein the ballast comprises at least one ballast tank or ballast container.
19. A wave power apparatus according to any claims 12-18, wherein the arm is connected to the shaft at at least two points along the shaft, which are offset from a centre axis of the arm, and wherein the shaft is rotatably supported by a fixed support structure which comprises two bearings arranged to counteract radial and axial forces.
20. A wave power apparatus according to claim 19, wherein the bearings are pre-stressed in an axial direction.
21. A wave power apparatus according to claim 19 or 20, comprising a plurality of arms and a plurality of shafts, so that each arm is supported by its own shaft, each arm being connected to its own shaft at at least two points along the shaft, which are offset from a centre axis of the arm, wherein each shaft is rotatably supported by the fixed support structure by two bearings arranged to counteract radial and axial forces.
22. A wave power apparatus according to any of claims 19-21, wherein each of the bearings comprises an inner and an outer ring or cylinder, the inner ring being secured to a rotational shaft of the arm, and the outer ring being secured to a fixed support, the bearing further comprising a flexible material between the inner and the outer ring.



23. A wave power apparatus according to claim 22, wherein the flexible material comprises at least one cavity or perforation.
24. A wave power apparatus according to claim 22 or 23, wherein the flexible material comprises at least one spring member, such as a flat spring.
- 5 25. A wave power apparatus according to any of the preceding claims, further comprising a hydraulic lifting system for lifting the float out of the ocean and for locking the float in an upper position above the ocean surface.
- 10 26. A wave power apparatus according to claim 9 and 25, wherein the double-acting cylinder forms part of the hydraulic lifting system, so that the cylinder is controllable to lift the float out of the ocean.

## PATENT COOPERATION TREATY

PCT

NOTIFICATION CONCERNING  
SUBMISSION OR TRANSMITTAL  
OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

From the INTERNATIONAL BUREAU

To:

INSPICOS A/S  
Bøge Allé 3  
P.O. Box 45  
DK-2970 Hørsholm  
Denmark

Date of mailing (day/month/year) 05 November 2004 (05.11.2004)	
Applicant's or agent's file reference 15931PCT00	<b>IMPORTANT NOTIFICATION</b>
International application No. PCT/DK2004/000704	International filing date (day/month/year) 14 October 2004 (14.10.2004)
International publication date (day/month/year) Not yet published	Priority date (day/month/year) 14 October 2003 (14.10.2003)
Applicant WAVE STAR ENERGY ApS et al	

- By means of this Form, which replaces any previously issued notification concerning submission or transmittal of priority documents, the applicant is hereby notified of the date of receipt by the International Bureau of the priority document(s) relating to all earlier application(s) whose priority is claimed. Unless otherwise indicated by the letters "NR", in the right-hand column or by an asterisk appearing next to a date of receipt, the priority document concerned was submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b).
- (If applicable) The letters "NR" appearing in the right-hand column denote a **priority document which, on the date of mailing of this Form, had not yet been received by the International Bureau** under Rule 17.1(a) or (b). Where, under Rule 17.1(a), the priority document must be submitted by the applicant to the receiving Office or the International Bureau, but the applicant fails to submit the priority document within the applicable time limit under that Rule, **the attention of the applicant is directed to Rule 17.1(c)** which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.
- (If applicable) An asterisk(\*) appearing next to a date of receipt, in the right-hand column, denotes a **priority document submitted or transmitted to the International Bureau but not in compliance with Rule 17.1(a) or (b)** (the priority document was received after the time limit prescribed in Rule 17.1(a) or the request to prepare and transmit the priority document was submitted to the receiving Office after the applicable time limit under Rule 17.1(b)). Even though the priority document was not furnished in compliance with Rule 17.1(a) or (b), the International Bureau will nevertheless transmit a copy of the document to the designated Offices, for their consideration. In case such a copy is not accepted by the designated Office as priority document, Rule 17.1(c) provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

<u>Priority date</u>	<u>Priority application No.</u>	<u>Country or regional Office or PCT receiving Office</u>	<u>Date of receipt of priority document</u>
14 Octo 2003 (14.10.2003)	PCT/DK2003/00693	DK	28 Octo 2004 (28.10.2004)

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